The role of large-scale environment and convective diurnal cycle in the propagation of the MJO over the Maritime Continent

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Motivation

- The Madden-Julian Oscillation (MJO), a large-scale disturbance of heavy rainfall that propagates eastward from the tropical Indian Ocean to the West Pacific on a timescale of 30-60 days, has profound impacts on downstream weather across the western hemisphere.
- Up to 50% of the time MJOs stall over the Maritime Continent (MC) for reasons we do not understand yet.
- Such a barrier effect of the MC on the MJO is poorly represented in current weather and climate models, severely limiting their subseasonal-to-seasonal (S2S) forecast capabilities.
- It has been hypothesized that large-scale moisture structure and the interaction between MJO and the diurnal cycle of convection over the MC may play a role in the MC barrier effect.

Objective

- Compare large-scale environmental conditions and diurnal cycle of precipitation over the MC for crossing MJOs (MJOC) and blocking MJOs (MJOB) during the TRMM/GPM observing period
- Perform convection-permitting model simulations to understand the physical processes that are responsible for the MC barrier effect

MJO composites based on Large-scale Precipitation Tracking (LPT, Kerns and Chen 2016)

- MJOC: 26 cases (~152 days) when MJO centered between 100E and 120E
- MJOB: 18 cases (~50 days) when MJO center between 100E and 120E

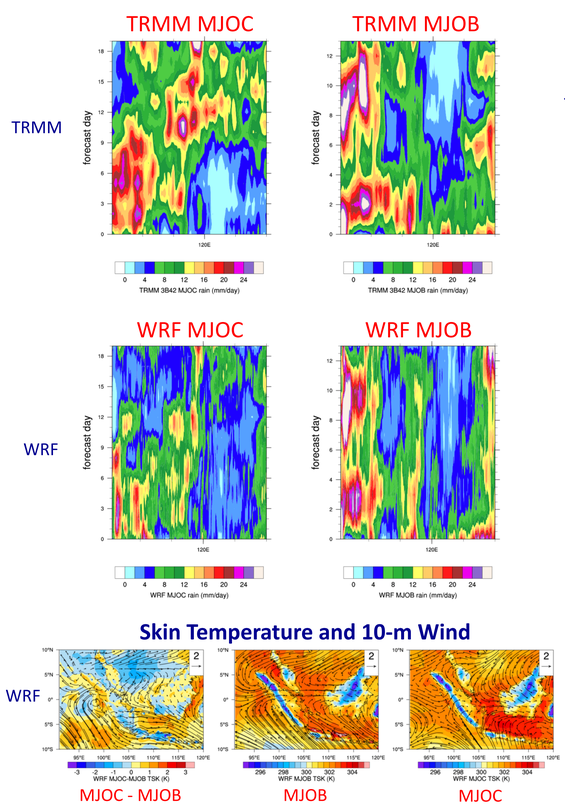
Selected MJO cases

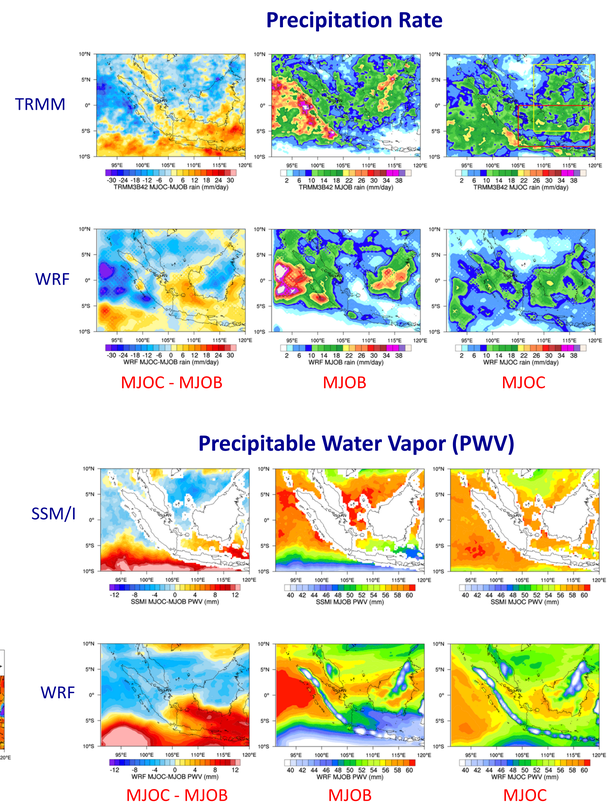
- MJOC: Nov. 20, 2014 – Dec. 09, 2014
- MJOB: Nov. 01, 2012 – Nov. 14, 2012

WRF model set-up

- WRF V3.8.1
- Three-nested domains: 36 km, 12 km and 4 km, respectively
- 50 vertical levels from the surface to 50 hPa
- Initial and boundary conditions: ERA-Interim
- SST updated every 6 hour
- Model physics:
  - Tiedtke cumulus scheme at 36 km and 12 km, no cumulus at 4 km
  - Morrison 2-moment microphysics
  - RRTMG shortwave and longwave schemes
  - Noah land surface
  - YSU PBL

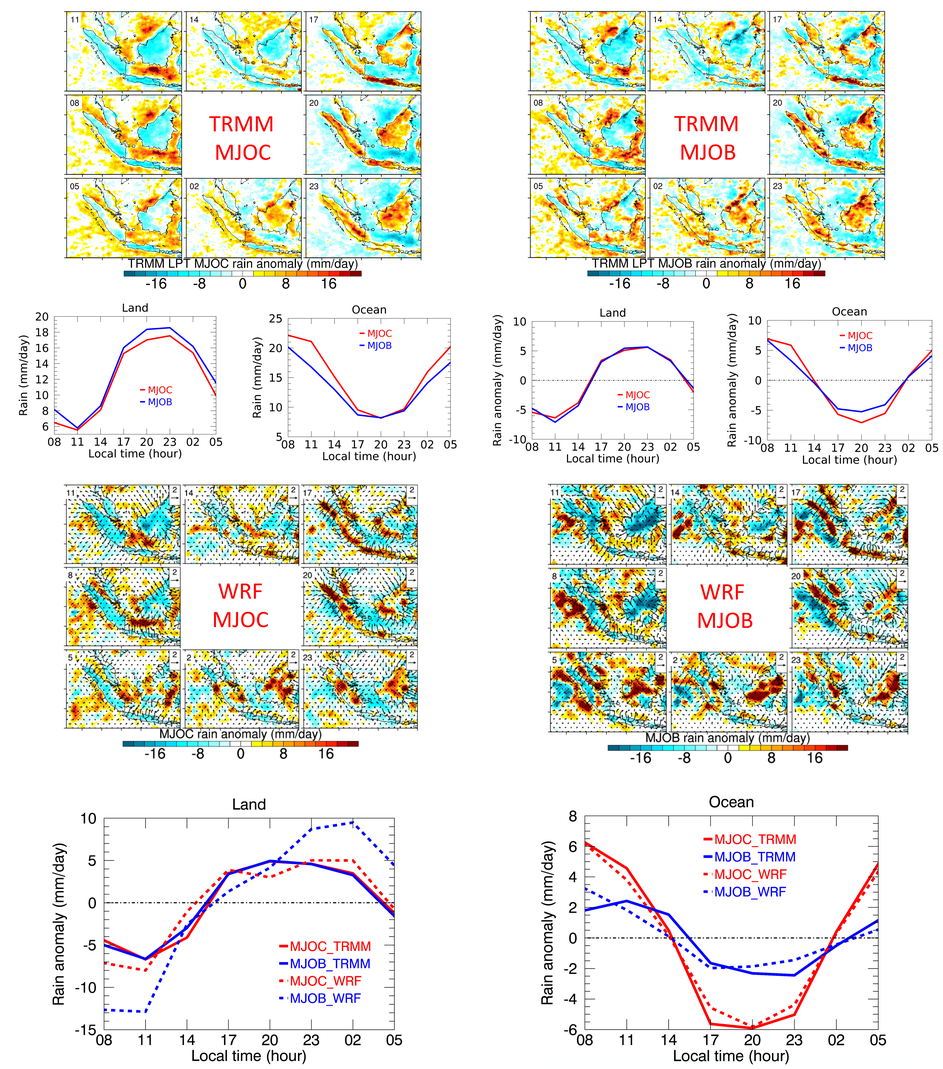
Results – Daily means





Results – Diurnal variations (daily mean removed)

Composite diurnal cycle for MJOC and MJOB events based on LPT (1998-2015)



Summary

- The crossing MJOs are associated with warmer SST and higher water vapor over the open water in the MC than the blocking MJOs, while the land surface temperature exhibits inhomogeneous mixed differences between the two types of MJOs.
- Over the water, the crossing MJOs are associated with stronger diurnal variation of rainfall than the blocking MJOs.
- Over the land, the crossing MJOs are associated with similar diurnal variation of rainfall to the blocking MJOs.
- WRF simulations approximately capture the two MJO events but with weaker amplitude of precipitation and its propagation features. Sensitivity experiments will be conducted to test the roles of environment and convective diurnal cycle.

Acknowledgements

We thank the funding support from NASA PMM. This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA.

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